jc542 U.S. PTO
02/23/99

SIDLEY & AUSTIN
A PARTNERSHIP INCLUDING PROFESSIONAL CORPORATIONS

717 NORTH HARWOOD
DALLAS, TEXAS 75201
TELEPHONE 214 981 3300
FACSIMILE 214 981 3400

CHICAGO
LOS ANGELES
NEW YORK

WASHINGTON, D.C.
LONDON
SINGAPORE
TOKYO

FOUNDED 1866

WRITER'S DIRECT NUMBER
(214) 981-3328

jc612 U.S. PTO
09/255352
02/23/99

February 23, 1999

Assistant Commissioner for
Patents
Box Patent Application
Washington, D.C. 20231

"Express Mail" mailing label
number EL081817830US

Date of Deposit February 23, 1999
I hereby certify that this paper or fee is being deposited with the United States Postal Service "Express Mail Post Office to Addressee" service under 37 CFR 1.10 on the dated indicated above and is addressed to the Assistant Commissioner for Patents, Washington, D.C. 20231, on

Derrick T. Gordon
(Typed or printed name of person mailing paper or fee)

Derrick T. Gordon
(Signature of person mailing paper or fee)

February 23, 1999
Date of Signature

Re: U.S. Patent Application
AN IMAGE SEARCHING SYSTEM AND IMAGE SEARCHING METHOD, AND A RECORDING MEDIUM STORING AN IMAGE SEARCHING PROGRAM
By: Sumiyo TANAKA
Attorney Docket: 15162/00200

Dear Sir:

Enclosed for filing are the following papers relating to AN IMAGE SEARCHING SYSTEM AND IMAGE SEARCHING METHOD, AND A RECORDING MEDIUM STORING AN IMAGE SEARCHING PROGRAM, Sumiyo TANAKA, inventor:

(1) Specification;

(2) Executed Declaration and Power of Attorney;

(3) Formal Drawings (9 sheets);

(4) Certified Copy of Priority Document;

(5) Assignment with recordation sheet;

(6) Information Disclosure Statement, along with Form 1449 and copies of references;

(7) Check in the amount of $1408.00 to cover the filing fee of the application; and

(8) Check in the amount of $40.00 to cover the assignment recordation fee.

In the event the attached checks in the amounts of $1408.00 and $40.00 are not received with this correspondence, are not sufficient, or in the event additional fees are due, please charge the required fees (other than issue fee) during the pendency of this application to Deposit Account No. 18-1260. Please credit any overpayment to Deposit Account No. 18-1260.

All correspondence is to be directed to the Applicant's attorney at the Dallas address listed above.

Respectfully submitted,

James W. Williams

James W. Williams
Registration No. 20,047
Attorney for Applicant

JWW/skp
Enclosures

An image searching system and image searching method, and a recording medium storing an image searching program

BACKGROUND OF THE INVENTION

Field of the Invention

The present invention relates generally to an image searching system for finding an image that resembles a specified image from among images managed by the image searching system where the search criteria are determined from the specified image. The present invention relates more specifically to an image searching system for finding an image based on a plurality of specified images.

Description of the Related Art

Images stored to a database for managing image data are typically stored with additional information that can be used to specify search conditions, including search keys, such as identifying keywords and image color keys, and image features, such as information on the shapes and colors appearing in the image. Using this common type of image database, it is possible to search the stored images to find an image similar to a user-specified image.

Image similarity in similar-image searching is determined based on such feature quantities as image shape, texture, and color. More specifically, the user specifies

an image in the image database that is similar to a desired image to be searched for. Feature quantities are then extracted from the image selected by the user as the search key (referred to below as the "key image"), and the extracted feature quantities are then compared with the feature quantities registered in the image database. Image similarity indicative of the similarity between the key image and a found image is then calculated. Information on any stored image determined to resemble the key image based on this calculated image similarity is then returned as the search result.

Usually there is only one key image selected by the user, and it is often impossible to find the one image sought by the user based on the feature quantities defined from a single key image. Search accuracy is therefore often low. This can happen, for example, when there are plural features in a single image and the user focuses on only one feature, that is, when the user's search criteria are narrower than the criteria that can be extracted from the key image, as well as when numerous search conditions are specified to broaden the range of the search.

Japanese Patent Laid-Open Publication 7-65169 teaches one method proposing to solve this problem. According to the taught method, a plurality of key images is specified, a specific area in each of the key images is

selected, and the features to be used as search criteria are extracted from the selected areas. The search is then conducted using these features from plural selected areas in plural images. This method thus makes it possible to search for images having all of the features found in the specified areas of the plural key images. In other words, this method enables the user to specify a wide range of search conditions based on plural images.

The drawback to said taught method is that the user is required to specify in each of the selected key images those features that are to be used for searching, and this task becomes increasingly difficult and time-consuming as the number of key images increases and the variety of selected features increases.

The present invention is therefore directed to an image searching system and an image searching method for reducing the user burden and improving search accuracy when a plurality of key images is specified and a desired image is searched for based on these selected key images.

The present invention is further directed to a recording medium for storing an image searching program embodying the image searching method of the present invention.

SUMMARY OF THE INVENTION

A first image searching system according to the present invention comprises: an image storage means for storing a plurality of target images for searching; a selection means for selecting a plurality of key images for determining the search criteria; a first feature quantity extraction means for extracting one or a plurality of feature quantities from each of the plurality of key images selected by the selection means; a second feature quantity extraction means for extracting one or a plurality of feature quantities from a target image; a feature quantity identification means for comparing a feature quantity extracted by the first feature quantity extraction means with the same type of feature quantity in each of the plurality of key images to determine a feature quantity to be used for searching; a degree of similarity calculating means for calculating a degree of similarity between a target image and key image using the feature quantity identified by the feature quantity identification means for searching; and an extraction means for extracting as an image similar to a key image any target image for which the degree of similarity calculated by the degree of similarity calculating means exceeds a specific value.

Thus comprised, this first image searching system compares features extracted from plural key images to determine the features to be used as search criteria, and

then calculates image similarity using the identified features (feature quantities).

In this first image searching system, the feature quantity identification means preferably defines as a feature quantity type to be used for searching a feature quantity type having an approximately equal value in each of the compared key images.

A second image searching system according to the present invention comprises: an image storage means for storing a plurality of target images for searching; a selection means for selecting a plurality of key images for determining the search criteria; a first feature quantity extraction means for extracting a feature quantity from each of the plurality of key images selected by the selection means; a second feature quantity extraction means for extracting a feature quantity from a target image; a first degree of similarity calculating means for calculating a first degree of similarity indicative of the similarity between a target image and all of the plurality of key images using the feature quantities extracted by the first and second feature quantity extraction means; a second degree of similarity calculating means for calculating a second degree of similarity indicative of the similarity between a target image and at least one of the plurality of key images using the feature quantities

extracted by the first and second feature quantity extraction means; a third degree of similarity calculating means for calculating a third degree of similarity from the first and second degrees of similarity where the first degree of similarity is weighted greater than the second degree of similarity; and an extraction means for extracting as an image similar to a key image any target image for which the third degree of similarity calculated by the third degree of similarity calculating means exceeds a specific value. The third degree of similarity in this case is calculated with greater weight assigned to the first degree of similarity than to the second degree of similarity

A first image searching method according to the present invention searches in a plurality of stored target images for an image that is similar to a key image based on the key image. This first image searching method comprises: a selection step for selecting a plurality of key images; a first feature quantity extraction step for extracting one or a plurality of feature quantity types from each of the plurality of selected key images; a second feature quantity extraction step for extracting one or a plurality of feature quantity types from the target images; a feature quantity identification step for comparing a feature quantity extracted by the first feature quantity extraction

step with the same type of feature quantity in each of the plurality of key images to determine a feature quantity type to be used for searching; a degree of similarity calculating step for calculating a degree of similarity between a target image and key image using the feature quantity type identified for searching; and an extraction step for extracting as an image similar to a key image any target image for which the calculated degree of similarity exceeds a specific value.

A second image searching method for searching in a plurality of stored target images for an image that is similar to a key image based on said key image comprises: a selection step for selecting a plurality of key images; a first feature quantity extraction step for extracting a feature quantity from each of the plurality of selected key images; a second feature quantity extraction step for extracting a feature quantity from a target image; a first degree of similarity calculating step for calculating a first degree of similarity indicative of the similarity between a target image and all of the plurality of key images using the feature quantities extracted by the first and second feature quantity extraction steps; a second degree of similarity calculating means for calculating a second degree of similarity indicative of the similarity between a target image and at least one of the plurality of

key images using the feature quantities extracted by the first and second feature quantity extraction steps; a third degree of similarity calculating step for calculating a third degree of similarity from the first and second degrees of similarity where the first degree of similarity is weighted greater than the second degree of similarity; and an extraction step for extracting as an image similar to a key image any target image for which the third degree of similarity exceeds a specific value.

A first recording medium according to the present invention is a computer-readable recording medium for recording an image searching program where the image searching program embodies a method for searching in a plurality of stored target images for an image that is similar to a key image based on said key image. Specific steps in this image searching program include: a selection step for selecting a plurality of key images; a first feature quantity extraction step for extracting one or a plurality of feature quantity types from each of the plurality of selected key images; a second feature quantity extraction step for extracting one or a plurality of feature quantity types from the target images; a feature quantity identification step for comparing a feature quantity extracted by the first feature quantity extraction step with the same type of feature quantity in each of the

plurality of key images to determine a feature quantity type to be used for searching; a degree of similarity calculating step for calculating a degree of similarity between a target image and key image using the feature quantity type identified for searching; and an extraction step for extracting as an image similar to a key image any target image for which the calculated degree of similarity exceeds a specific value.

A second recording medium according to the present invention is also a computer-readable recording medium for recording an image searching program. Specific steps in this image searching program include: a selection step for selecting a plurality of key images; a first feature quantity extraction step for extracting a feature quantity from each of the plurality of selected key images; a second feature quantity extraction step for extracting a feature quantity from a target image; a first degree of similarity calculating step for calculating a first degree of similarity indicative of the similarity between a target image and all of the plurality of key images using the feature quantities extracted by the first and second feature quantity extraction steps; a second degree of similarity calculating means for calculating a second degree of similarity indicative of the similarity between a target image and at least one of the plurality of key

images using the feature quantities extracted by the first and second feature quantity extraction steps; a second degree of similarity calculating means for calculating a second degree of similarity indicative of the similarity between a target image and at least one of the plurality of key images using the feature quantities extracted by the first and second feature quantity extraction steps; a third degree of similarity calculating step for calculating a third degree of similarity from the first and second degrees of similarity where the first degree of similarity is weighted greater than the second degree of similarity; and an extraction step for extracting as an image similar to a key image any target image for which the third degree of similarity exceeds a specific value.

BRIEF DESCRIPTION OF THE DRAWINGS

These and other objects and features of the present invention will be readily understood from the following detailed description taken in conjunction with preferred embodiments thereof with reference to the accompanying drawings, in which like parts are designated by like reference numerals and in which:

Fig. 1 is a typical overview of an image searching system according to a preferred embodiment of the present invention;

Fig. 2 is a block diagram of primarily the control device of the image searching system shown in Fig. 1;

Fig. 3 shows a typical image database table structure;

Fig. 4 is a flow chart of the main loop of the image searching method embodied in the image searching system shown in Fig. 1;

Fig. 5 is a flow chart of the image registration process shown as step S3 in Fig. 4;

Fig. 6 is a flow chart of the similar image searching process shown as step S4 in Fig. 4;

Fig. 7 is a flow chart of the search feature compilation process shown as step S43 in Fig. 6;

Fig. 8 is a data table used to describe a method of calculating common features;

Fig. 9 is a data table of sample feature quantities extracted from a key image;

Fig. 10 is a data table of sample feature quantities extracted from a target image;

Fig. 11 is a data table used to describe similarity calculation based on common feature quantities;

Fig. 12 is a flowchart of the similar image searching process shown as step S4 in Fig. 4, that is executed according to a second preferred embodiment of the

present invention; and

Fig. 13 is a flowchart of the search feature compilation process shown as step S43 in Fig. 6, that is executed according to the second preferred embodiment of the present invention.

Fig. 14 is a data table used to describe similarity calculation based on all feature quantities;

Fig. 15 is a data table used to describe similarity calculation based on a degree of similarity based on common feature quantities and a degree of similarity based on all feature quantities.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

The preferred embodiments of an image searching system according to the present invention are described below with reference to the accompanying figures. An image searching system according to the present invention searches for an image similar to common features found in a plurality of specified key images. The image searching system extracts one or a plurality of feature quantities from the plural key images and compares similar feature quantities in the key images to determine the types of feature quantities to use for searching. The degree of similarity is then calculated using the specified feature quantity types, and an image search is then conducted based

on this degree of similarity. It is therefore possible to search for images having features common to a plurality of key images.

The image searching system of the present invention can alternatively calculate the degree of similarity using both a degree of similarity indicative of the resemblance to all of the plural key images, and a degree of similarity indicative of the resemblance to one or some larger subset of the plural key images. This method makes it possible to expand the range of the search, and thus improve search accuracy.

Overall configuration of the image searching system

Fig. 1 shows the basic configuration of an image searching system, referred to as the "system" below, according to a preferred embodiment of the present invention. As will be known from Fig. 1, this system is built around a control device 1 for controlling the overall system and comprising a central processing unit (CPU). Connected to this exemplary control device 1 are: a display 2 for displaying text and images, as well as control prompts and other interface elements; a keyboard 3 and mouse 4 for data entry and operating the system; a floppy disk drive 5b in which a floppy disk 5a can be used and a hard disk drive 6 for reading and writing data to a data

storage medium; a printer 7 for printing text and images to hard copy; a scanner 8 for capturing image data; a CD-ROM drive 9b for accessing data stored to a CD-ROM 9a; a speaker 10 for audio output; and a microphone 11 for audio input.

Fig. 2 is a block diagram of the image searching system shown in Fig. 1.

Connected directly to the CPU 201 is a clock 202 for generating the reference clock required to regulate system operations. A ROM 203 for storing an application program for controlling the image searching system, and a RAM 204 for temporarily storing data and programs used by the CPU 201 for system control, are connected to the CPU 201 via a data bus 220. Circuits connected to the CPU 201 via the data bus 220 include: a display control circuit 205 for controlling the display 2 to display text and graphics; a keyboard control circuit 206 for controlling transfer of input from the keyboard 3; a mouse control circuit 207 for controlling transfer of input from the mouse 4; a floppy disk drive control circuit 208 for controlling the floppy disk drive 5b; a hard disk drive control circuit 209 for controlling the hard disk drive 6; a printer control circuit 210 for controlling output to the printer 7; a scanner control circuit 211 for controlling the scanner 8; a CD-ROM drive control circuit 212 for controlling the CD-

ROM drive 9b; a speaker control circuit 213 for controlling the speaker 10; and a microphone control circuit 214 for controlling the microphone 11. An expansion slot 215 for connecting different types of system expansion boards is also connected via the data bus 220.

It should be noted that a SCSI board, for example, can be connected to the expansion slot 215 and used for connecting a floppy disk drive 5b, hard disk drive 6, scanner 8, CD-ROM drive 9b, or other device.

It should also be noted that while a floppy disk 5a and hard disk drive 6 are the preferred image data storage means in this exemplary system, the invention shall obviously not be limited thereto as any other data storage medium that the system can use can be used for image data storage, including magneto-optical (MO) disks [and DVD disks].

Furthermore, while a scanner 8 is used in this exemplary system for image data capture and input, other data input devices can also be used, including video still cameras and digital cameras.

In addition, while a printer 7 is used as an output device, a digital photocopier or other type of hard copy output device can also be used.

A program embodying the control method of the present invention is also stored to ROM 203 in this

preferred embodiment. This control program, however, can be alternatively stored in whole or in part to another data storage medium, including a floppy disk 5a, hard disk drive 6, or CD-ROM 9a. In this case, the required data and program content can be read from the data storage medium as needed, buffered to RAM 204, and executed from RAM 204.

Image database

To store and manage image data, an image searching system according to this preferred embodiment also has an image database and a color space table. The image database contains both the image data and additional information used for the search keys. The color space table is referenced when extracting color features from an image. Both the image database and color space table are logic objects stored on the hard disk drive 6 or other data storage medium.

An exemplary image database 50 in the present system is shown in Fig. 3. As will be known from Fig. 3, this image database 50 manages the image data to be searched, and various columns of image attributes that are used as search parameters for finding desired image data. These image attributes include keywords, a color key, and other search keys, and various feature quantities indicative of specific features in the image data. More

specifically, these feature quantities include a color feature indicative of features relating to image color, a shape feature indicative of shapes in the image, and a texture feature indicative of texture patterns. The similarity between images is calculated based on this feature information.

Controlling the image searching system

A specific method of controlling the above-described image searching system is described next below with reference to the accompanying flow charts.

Main loop of the control program

Fig. 4 is a flow chart of the main loop of a control program run by the CPU 201 in the image searching system shown in Fig. 1.

The procedure starts by initializing the various flags and variables used in the rest of the procedure, and to display the default menus (S1). An exemplary default menu screen displays various icons representing and used for selecting specific processes such that when a user selects one of the icons, the corresponding process is executed. It should be further noted that the system of this preferred embodiment enables the operator to select various processes and enter information using the keyboard

3 and mouse 4 from the default menu screen and other screens that are displayed on the display 2. After initialization in step S1, decision diamond S2 detects whether the user has selected a menu item from the default menu screen (S2).

If in step S2 the user selects "register image," for example, the image registration process (S3) is selected and run, and the procedure then advances to step S6. This image registration process (S3) is run to store image data and related feature information in the image database 50, and is described in further detail below with reference to the flow chart in Fig. 5.

If in step S2 the user selects "search for similar image," for example, the similar image searching process (S4) is selected and run, and the procedure then advances to step S6. This similar image searching process (S4) is run to search in the image database 50 for an image similar to a selected key image, and is described in further detail below with reference to the flow chart in Fig. 6.

If in step S2 the user selects another menu item, the corresponding process (S5) is selected and run, and the procedure then advances to step S6.

If no menu item is selected in S2, the procedure advances directly to step S6. After the procedure defined

for step S6 is run and completed, the main loop returns to step S2 and repeats.

It should be noted that the tasks that might be performed as the "other menu process" selected in S5 are not unique to or directly related to the present invention, and further description thereof is thus omitted below. The image registration process (S3) and the similar image searching process (S4) of the present invention are described next in detail below.

Image registration process

The image registration process shown as step S3 in Fig. 4 is described next in detail below with reference to the flow chart in Fig. 5. This process extracts feature quantities from a user-specified image to be stored in the image database, and then stores the specified image and extracted features to the image database 50.

This routine starts by reading the user-specified image to be stored to the image database 50 (S31). A feature extraction process is then run (S32) to extract feature quantities from the specified image. In this preferred embodiment of the invention, the extracted feature quantities include color, shape, and texture, but the invention shall obviously not be limited thereto. The extracted feature quantities are then related* to the image

data of the specified image (S33), and finally registered in the image database 50 together with the related specified image data (S34). A file name, image size information, and other image attributes are also normally stored with or related to the image data. The procedure then returns to the main loop (step S6 in Fig. 4).

[* NOTE: I've used "related" here because the database could be a flat file or relational database, and "related" will cover the association between feature quantities and image data for both database types (the tables in the illustrations seem to imply a flat-file (non-relational) database structure).]

Similar image searching processing

(a) Similar image search based on common feature quantities (first embodiment)

According to first embodiment, common feature quantities are extracted from a plurality of key images. Upon evaluating a similarity of a target image to a key image, only these common feature quantities are used for calculating a degree of similarity of the target image to a key image. In other words, feature quantities other than the common feature quantities are not used for calculation of the degree of similarity.

The similar image searching processing according

to first embodiment (shown as step 4 in Fig. 4) is described below with reference to a flow chart shown in Fig. 6. In the present processing, predetermined feature quantities are extracted from each of plural key images specified by a user and feature quantities indicative of features common to the plural key images are selected as common feature quantities among the extracted feature quantities. Then, the searching processing is performed to find out an image similar to a key image among images registered in the image database 50 based on the common feature quantities.

Referring to Fig. 6, at first, a plurality of key images specified by a user are read (step S41). Feature quantities of each key image are extracted from the image database 50 (step S42). In this step, feature quantities of plural kinds such as color, shape, texture and so on are obtained from each key image. Next, a search feature quantity compilation processing is performed to calculate common feature quantities for searching a similar image by comparing the feature quantities of respective key images with each other (step S43). This search feature quantity compilation processing will be described later.

Thereafter, to find an image among images registered in the image database 50 which is similar to the key images, the common feature quantities calculated in

step S43 are compared with feature quantities of each image registered in the image database, and the degree of similarity between the key images and the presently selected image is calculated (from step S44 to step S46).

Namely, it is determined if there is an image in the image database 50 for which the degree of similarity to the key images has not yet been calculated (herein below referred to as a "target image")(step S44). If such a target image is present in the image database 50, the feature quantities for that target image are read from the image database 50 (step S45). Then, a degree of similarity indicative of a similarity between the target image and each key image is calculated based on the common feature quantities of the key images and the feature quantities of the key images and the feature quantities of the target image (step S46) and the processing loops back to step S43. This calculation processing of the degree of similarity will be described later. These steps S43 to S45 are repeated until the similarity calculation has been completed for all target images in the image database.

When the degree of similarity has been calculated for all target images in the image database 50, an output processing of search results is performed (step S47) and the processing returns to the main routine. In the output processing of the search results, it is determined that

those target images for which the calculated degree of similarity exceeds a predetermined threshold value are similar to the key images. The target images determined to be similar are then displayed on screen in turn from the highest degree of similarity.

Alternately, without providing any threshold for determination of the similarity, a predetermined number of target images can be displayed in a descending order from the highest degree of similarity. Further, the search results can be displayed by simply outputting the file name of the target image data, preferably with related attributes such as its location in the database. The target images tested by the search loop from step S44 to step S46 shall also not be limited to all of the images stored in the image database 50. For instance, only images preselected based on predetermined conditions can be tested.

The search feature quantity compilation processing (step S43 in Fig. 6) is described next with reference to a flow chart shown in Fig. 7. This processing calculates the common feature quantities to be used upon searching a target image which is similar in common to a plurality of key images. That is, the common feature quantities indicative of features in common to a plurality of key images are obtained by comparing feature quantities of the same kind among the plurality of key images and

choosing feature quantities of the same kind having values being approximate to each other as the common feature quantities. This processing is described in further detail below.

As shown in Fig. 7, the processing starts by calculating, for every kind of the feature quantity, differences among the feature quantities of the key images (step S431). Next, a mean value of the differences obtained in step S431 is calculated for every kind of the feature quantity (S432). An example of this calculation is shown in Fig. 8. This figure shows an example obtained for three key images 1 to 3 each having five feature quantities 1 to 5 as shown in Fig. 9. The mean value of the differences with respect to the same feature quantity indicates the smaller the mean value the greater the image similarity with respect to that feature quantity.

Thereafter, every feature quantity or the kind of the feature quantity having a mean value equal to or less than a predetermined threshold is selected as a common feature quantity (step S433). That is, when the mean feature quantity difference is less than the threshold value, that feature quantity is determined to be common to the plural key images. In the example shown in Fig. 8, this threshold value is set to 0.1 and feature quantity 2 and feature quantity 3 are thus selected as common feature

quantities. Thus, the feature quantities or kinds of feature quantities to be used for searching are determined by comparing feature quantities of the same kind in the key images. In the last step, a specific flag is set for every feature quantity selected as a common feature quantity (step S434).

Next, the processing for calculating the degree of similarity (step S46 in Fig. 6) is described below. Based on the common feature quantities extracted from the key images and a target image, this processing calculates the degree of similarity of the target image to all key images or either one of them.

According to the present embodiment, only feature quantities selected as common feature quantities in step S43 are used for calculating the degree of similarity of the target image to the key image.

Accordingly, feature quantities other than common feature quantities are not used for the calculation of the degree of similarity. Due to this, images having features common to plural key images can be obtained as the results of search with a high accuracy. In this case, the target image similar to all of the plural key images. In other words, this search method imposes a search under an AND condition among the key images and thereby, enables to restrict ranges of searching conditions to reasonable ones.

Fig. 11 shows an example of the calculation for the degree of similarity. In this example, the distance between each key image and the target image is calculated based on the values of feature quantity 2 and feature quantity 3 selected as the common feature quantities and the degree of similarity is obtained based on the calculated distances. The values shown in Fig. 11 are obtained from the following equations (1) to (3).

Difference between feature quantities = |(key image feature quantity)-(target image feature quantity)| (1)

Distance = square root of sum of (each feature quantity difference)^2 (2)

Degree of similarity = 1.0/distance (3)

The degree of similarity thus obtained indicates that the image similarity becomes high as the calculated value of the degree of similarity becomes large.

(b) Similar image searching based on all kinds of feature quantities (second embodiment)

According to second embodiment, the degree of similarity between a target image and key images is calculated for each of the key images based on feature quantities of all kinds. From the degrees of similarity calculated for each key image, the highest degree of similarity is then selected as the degree of similarity of the target image to the corresponding key image. In this

case, images similar to at least one of the plural key images are searched. That is, the image search is performed under an OR logic condition and, accordingly, it becomes possible to broaden the ranges of searching conditions by increasing the number of key images. Second embodiment performs a processing shown in Fig. 12 and Fig. 13 instead of Figs. 6 and 7 of first embodiment.

Referring to Fig. 12, a plurality of key images specified by a user are read at first (S141). Feature quantities are obtained from the image database 50 for each key image (S142). Namely, feature quantities of plural kinds such as color, shape, texture and the like are obtained form each key image.

Then, the feature quantities of each key image obtained in step S142 are compared with feature quantities of each target image registered in the image database 50, the similarity between each key image and the target image is determined and thereby, target images being similar to respective key images are searched (steps from S143 to S145).

At first, it is determined whether or not there is a target image in the image database for which the degree of similarity to each key image has not yet calculated (step S143). If such a target image is present in the image database 50, the feature quantities for that

target image are read from the image database (step S144). Then, calculation of the degree of similarity indicative of similarity between images is performed based on the feature quantities of each key image and those of the target image (step S144). After this calculation, the processing loops back to step S143. This calculation processing of the degree of similarity (step S145) will be described later. These steps S143 to S145 are repeated until the similarity calculation has been completed for all target images in the image database 50.

When the degree of similarity has been calculated for all target images in the image database 50, an output processing of search results is performed (step S147) and then, the processing returns to the main routine. In this output processing of search results (step S146), based on the degrees of similarity calculated for all target images in the image database 50, the key image having a degree of similarity higher than a predetermined threshold value is determined to be similar to the corresponding key image. The target images determined to be similar are then display on screen in sequence from the highest degree of similarity.

Alternately, without providing any threshold for determination of the similarity, a predetermined number of target images can be displayed in a descending order from the highest degree of similarity. Further, the search

results can be displayed by simply outputting the file name of the target image data, preferably with related attributes such as its location in the database. The target images tested by the search loop from step S144 to step S146 shall also not be limited to all of the images stored in the image database 50. For instance, only images preselected based on predetermined conditions can be tested.

Next, the calculation processing of degree of similarity is described below with reference to a flow chart shown in Fig. 13.

As shown in Fig. 14, a distance between a feature quantity of the key image and that of the same kind of the target image is calculated for each of all feature quantities, and a distance between the key images and the target image is calculated based on the distances of respective feature quantities.

Based on the distance between images, the degree of similarity is calculated (step S1451). More specifically, the values shown in Fig. 14 are obtained from the following equations (4) to (6).

Feature quantity distance = |(key image feature quantity)-(target image feature quantity)| (4)

Distance = sqrt of {sum of (each feature quantity distance)^2} (5)

Degree of similarity = 1.0/distance

Note that with this method image similarity increases as the calculated degree of similarity value rises. Because the degree of similarity to key image 3 is highest in the example shown in Fig. 14, that value is used as the degree of similarity between the current target image and the key images (step S1452).

The output processing of search results mentioned above with respect to step S146 is performed based on the degrees of similarity determined in step S1452.

(c) Similar image searching processing using degrees of similarity based on all feature quantities and degrees of similarity based on common feature quantities (third embodiment)

This method combines the degrees of similarity based on the common feature quantities calculated according to first embodiment (a) and those based on all feature quantities calculated according to second embodiment (b), to obtain final degrees of similarity. In this case, the degree of similarity based on common feature quantities is weighted and the weighted degree of similarity and the degree of similarity based on all feature quantities are added to obtain a mean value thereof. This mean value is assigned as the degree of similarity of the target image to the key image. Thus, this method performs a similar image search in combination of AND and OR conditions. As a

result, it becomes possible to find an image having features common to all key images among images similar to any one of the key images and therefore, to improve the search accuracy compared with second embodiment (b).

An example of the calculation of the degree of similarity is shown in Fig. 15. In this example, the weight for the degree of similarity a calculated in Fig. 11 is set larger than that for the degree of similarity calculated in Fig. 14. A weighted mean value is than calculated to obtain the final degree of similarity c. This final degree of similarity c is obtained according to the next equation (7).

Degree of similarity = {(degree of similarity a × weight wa)+(degree of similarity b × weight wb)} / (wa+wb)

(7)

As stated above, according to the present embodiment, feature quantities are extracted from a plurality of key images, when specified and those common to the plural key images are selected to determine similarity between images using these common feature quantities. Thus, the common feature quantities are automatically determined from among plural key images and accordingly, the user burden can be reduced. It is also possible to search for images having features common to plural key images. This enables to narrow the ranges of respective searching

conditions by specifying plural key images. Also, the search can be similarly expanded to broader ranges of searching conditions by considering the degree of similarity indicating similarity of an image to at least one of plural key images. Search accuracy can be thus improved.

As will be known from the above descriptions of the present invention, a first image searching system, a first image searching method, and a first recording medium storing an image searching program embodying the first image searching method of the invention determines the feature quantities to be used for image searching based on the feature quantities extracted from one or more key images, and calculates a degree of similarity using only the feature quantities selected as search criteria. It is therefore possible to search for images with features common to those of the selected key images. The search conditions can thus be restricted by specifying plural key images, and search accuracy can thus be improved. The user burden is also reduced because feature quantities are automatically extracted from the specified key images, and similar images are searched for based on the extracted feature quantities.

As will be known from the above descriptions of the present invention, a second image searching system, a

second image searching method, and a second recording medium storing an image searching program embodying the second image searching method of the invention calculates the degree of similarity used for searching by combining a degree of similarity indicative of similarity to all of the plurality of key image, and a degree of similarity indicative of similarity to any one of the plurality of key image. It is therefore possible to set a wide range of search criteria by selecting a plurality of key images, and further improve the accuracy of similar image searches.

Although the present invention has been described in connection with the preferred embodiments thereof with reference to the accompanying drawings, it is to be noted that various changes and modifications will be apparent to those skilled in the art. Such changes and modifications are to be understood as included within the scope of the present invention as defined by the appended claims, unless they depart therefrom.

What is claimed is:

1. An image searching system comprising:

an image database storing a plurality of database images to be searched for; a specifying controller for specifying a plurality of key images used to specify search conditions;

an extracting controller for extracting common feature values of common images from the plural key images specified by the specifying controller;

a calculating controller for comparing the common feature values, extracted by the extracting controller, with the feature values of the plural database images to thereby sequentially calculate similarities between the common feature values and the database image feature values; and

a searching controller for retrieving from the database images one of the images which is similar to the key image, based on a similarity calculated by the calculating controller.

2. The system as claimed in Claim 1, wherein the extracting controller includes:

an extracting means for extracting a plurality of types of the feature quantities from the respective key images specified by the specifying controller;

a selecting means for comparing the feature quantities, extracted by the extracting means, among the plural key images specified by the specifying controller to thereby select at least one of the types of the feature quantities; and

a determining means for determining the common feature quantities based on the at least one type of the features quantities selected by the selecting means.

3. The system as claimed in Claim 2, wherein the selecting means is operable to compare the feature quantities of the same types among the plural key images specified by the specifying controller and wherein the determining means is operable to calculate an average value of the feature quantities of the plural key image with respect to the types of the feature quantities selected by the selecting means, to thereby determine the calculated average value as representing the common feature quantities.

4. An image searching system which comprises:

an image database storing a plurality of database images to be searched for;

a specifying controller for specifying a plurality of key images used to specify search conditions;

a calculating controller for comparing the plural images, specified by the specifying controller, with the plural database images to thereby calculate similarities

between the common feature values and the database image feature values;

a selecting controller for retrieving a particular key image from the specified images based on the similarities calculated by the calculating controller; and

a searching controller for retrieving the images from the database images based on the similarity between the key image, selected by the selecting controller, and the database images.

5. The system as claimed in Claim 4, wherein the selecting controller is operable to select as a particular one of the plural specified key images, the key images which most resemble to the database images being searched for.

6. The system as claimed in Claim 5, wherein the calculating controller is operable to calculate a plurality of types of the feature quantities from the plural key images and then to calculate a degree of similarity by comparing the feature quantities with the database images for each type, and wherein the selecting controller selects, as the particular key image from the plural specified images, the key images which most resemble to the database images being searched with respect to an average value of degrees of similarities calculated by the calculating means for each type of the feature quantities.

7. An image searching system which comprises:

an image database storing a plurality of database images to be searched for;

a specifying controller for specifying a plurality of key images used to specify search conditions;

a first calculating controller for comparing all of the key images, specified by the specifying controller, with respective feature values of the database images to thereby calculate similarities therebetween;

a second calculating controller for selecting a particular key image from the plural key images specified by the specifying controller and for comparing the particular key image with the database images to thereby calculate similarities therebetween;

a third calculating controller for calculating a final similarity for use in searching based on the similarities calculated respectively by the first and second calculating controllers; and

a searching controller for retrieving one of the database images, which is similar to the particular key image, based on the final similarity calculated by the third calculating controller.

8. The image searching system as claimed in Claim 7, wherein the third calculating controller is operable to increase a weight of the degree of similarity, calculated

by the first calculating controller, to a value greater than that of the degree of similarity, calculated by the second calculating controller, to thereby calculate the final degree of similarity.

9. The image searching system as claimed in claim 8, wherein the first calculating controller is operable to extract the common feature quantities of the image common to all of the key images, and to compare those common feature quantities with the database image to thereby calculate the degree of similarity.

10. The image searching system as claimed in Claim 9, wherein the second calculating controller is operable to select the key images most similar to the database image from the key images and to calculate the degree of similarity.

11. An image searching method which comprises the steps of:

storing a plurality of database images to be searched for in a database;

specifying a plurality of key images used to specify search conditions by means of a specifying controller;

extracting by means of an extracting controller, common feature values of common images from the plural key images specified by the specifying controller;

comparing by means of a calculating controller, the

common feature values, extracted by the extracting controller, with the feature values of the plural database images to thereby sequentially calculate similarities between the common feature values and the database image feature values; and

retrieving from the database images one of the images which is similar to the key image, based on a similarity calculated by the calculating controller, by means of a searching controller.

12. The method as claimed in Claim 11, wherein the extracting step includes the sub-steps of extracting a plurality of types of the feature quantities from the respective key images specified by the specifying controller; comparing by means of a selecting means the feature quantities, extracted by the extracting sub-step, among the plural key images specified by the specifying controller to thereby select at least one of the types of the feature quantities; and determining the common feature quantities based on the at least one type of the features quantities selected by the selecting means.

13. The method as claimed in Claim 12, wherein the selecting means is operable to compare the feature quantities of the same types among the plural key images specified by the specifying controller and wherein the determining means is operable to calculate an average value

of the feature quantities of the plural key image with respect to the types of the feature quantities selected by the selecting means, to thereby determine the calculated average value as representing the common feature quantities.

14. An image searching method which comprises the steps of:

storing a plurality of database images to be searched for in an image database;

specifying a plurality of key images used to specify search conditions by means of a specifying controller;

comparing by means of a calculating controller, the plural images, specified by the specifying controller, with the plural database images to thereby calculate similarities between the common feature values and the database image feature values;

retrieving a particular key image from the specified images based on the similarities calculated by the calculating controller, by means of a selecting controller; and

retrieving the images from the database images based on the similarity between the key image, selected by the selecting controller, and the database images, by means of a searching controller.

15. The method as claimed in Claim 14, wherein the selecting controller is operable to select as a particular

one of the plural specified key images, the key images which most resemble to the database images being searched for.

16. The method as claimed in Claim 15, wherein the calculating controller is operable to calculate a plurality of types of the feature quantities from the plural key images and then to calculate a degree of similarity by comparing the feature quantities with the database images for each type, and wherein the selecting controller selects, as the particular key image from the plural specified images, the key images which most resemble to the database images being searched with respect to an average value of degrees of similarities calculated by the calculating means for each type of the feature quantities.

17. An image searching method which comprises the steps of:

storing a plurality of database images to be searched for in an image database;

specifying a plurality of key images used to specify search conditions by means of a specifying controller;

comparing all of the key images, specified by the specifying controller, with respective feature values of the database images to thereby calculate similarities therebetween, by means of a first calculating controller;

selecting by means of a second calculating controller,

a particular key image from the plural key images specified by the specifying controller and for comparing the particular key image with the database images to thereby calculate similarities therebetween;

calculating, by means of a third calculating controller, a final similarity for use in searching based on the similarities calculated respectively by the first and second calculating controllers; and

retrieving by means of a searching controller, one of the database images, which is similar to the particular key image, based on the final similarity calculated by the third calculating controller.

18. The image searching method as claimed in Claim 17, wherein the third calculating controller is operable to increase a weight of the degree of similarity, calculated by the first calculating controller, to a value greater than that of the degree of similarity, calculated by the second calculating controller, to thereby calculate the final degree of similarity.

19. The image searching method as claimed in claim 18, wherein the first calculating controller is operable to extract the common feature quantities of the image common to all of the key images, and to compare those common feature quantities with the database image to thereby calculate the degree of similarity.

20. The image searching method as claimed in Claim 19, wherein the second calculating controller is operable to select the key images most similar to the database image from the key images and to calculate the degree of similarity.

21. A recording medium storing therein a computer-executable image searching program, said program comprising:

storing a plurality of database images to be searched for in a database;

specifying a plurality of key images used to specify search conditions by means of a specifying controller;

extracting by means of an extracting controller, common feature values of common images from the plural key images specified by the specifying controller;

comparing by means of a calculating controller, the common feature values, extracted by the extracting controller, with the feature values of the plural database images to thereby sequentially calculate similarities between the common feature values and the database image feature values; and

retrieving from the database images one of the images which is similar to the key image, based on a similarity calculated by the calculating controller, by means of a searching controller.

22. The recording medium as claimed in Claim 21, wherein the extracting controller includes an extracting means for extracting a plurality of types of the feature quantities from the respective key images specified by the specifying controller; a selecting means for comparing the feature quantities, extracted by the extracting sub-step, among the plural key images specified by the specifying controller to thereby select at least one of the types of the feature quantities; and a determining means for determining the common feature quantities based on the at least one type of the features quantities selected by the selecting means.

23. The recording medium as claimed in Claim 22, wherein the selecting means is operable to compare the feature quantities of the same types among the plural key images specified by the specifying controller and wherein the determining means is operable to calculate an average value of the feature quantities of the plural key image with respect to the types of the feature quantities selected by the selecting means, to thereby determine the calculated average value as representing the common feature quantities.

24. A recording medium storing therein a computer-executable image searching program, said program comprising:

storing a plurality of database images to be searched for in an image database;

specifying a plurality of key images used to specify search conditions by means of a specifying controller;

comparing by means of a calculating controller, the plural images, specified by the specifying controller, with the plural database images to thereby calculate similarities between the common feature values and the database image feature values;

retrieving a particular key image from the specified images based on the similarities calculated by the calculating controller, by means of a selecting controller; and

retrieving the images from the database images based on the similarity between the key image, selected by the selecting controller, and the database images, by means of a searching controller.

25. The recording medium as claimed in Claim 24, wherein the selecting controller is operable to select as a particular one of the plural specified key images, the key images which most resemble to the database images being searched for.

26. The recording medium as claimed in Claim 25, wherein the calculating controller is operable to calculate a plurality of types of the feature quantities from the

plural key images and then to calculate a degree of similarity by comparing the feature quantities with the database images for each type, and wherein the selecting controller selects, as the particular key image from the plural specified images, the key images which most resemble to the database images being searched with respect to an average value of degrees of similarities calculated by the calculating means for each type of the feature quantities.

27. A recording medium storing therein a computer-executable image searching program, said program comprising:

storing a plurality of database images to be searched for in an image database;

specifying a plurality of key images used to specify search conditions by means of a specifying controller;

comparing all of the key images, specified by the specifying controller, with respective feature values of the database images to thereby calculate similarities therebetween, by means of a first calculating controller;

selecting by means of a second calculating controller, a particular key image from the plural key images specified by the specifying controller and for comparing the particular key image with the database images to thereby calculate similarities therebetween;

calculating, by means of a third calculating

controller, a final similarity for use in searching based on the similarities calculated respectively by the first and second calculating controllers; and

retrieving by means of a searching controller, one of the database images, which is similar to the particular key image, based on the final similarity calculated by the third calculating controller.

28. The recording medium as claimed in Claim 27, wherein the third calculating controller is operable to increase a weight of the degree of similarity, calculated by the first calculating controller, to a value greater than that of the degree of similarity, calculated by the second calculating controller, to thereby calculate the final degree of similarity.

29. The recording medium as claimed in claim 28, wherein the first calculating controller is operable to extract the common feature quantities of the image common to all of the key images, and to compare those common feature quantities with the database image to thereby calculate the degree of similarity.

30. The recording medium as claimed in Claim 29, wherein the second calculating controller is operable to select the key images most similar to the database image from the key images and to calculate the degree of similarity.

Abstract of the Disclosure

An image searching system, an image searching method, and a medium storing an image searching program for improving search accuracy while reducing the user burden when searching for similar images based on a plurality of key images are disclosed.

A plurality of feature quantity types is extracted from each of plural key images (S42), and feature quantities of the same type are compared between the key images to select those feature quantities having approximately equal values as the key image feature quantities to be used as search criteria (S43). Feature quantities in the target images are then extracted (S45) and a degree of similarity between the target image and key images is calculated based on a key image feature quantity and the same feature quantity in the target image (S46). Based on the resulting degree of similarity, target images having a high similarity to the key image are output as the search result (S47).

6662260 2005260

Fig.1

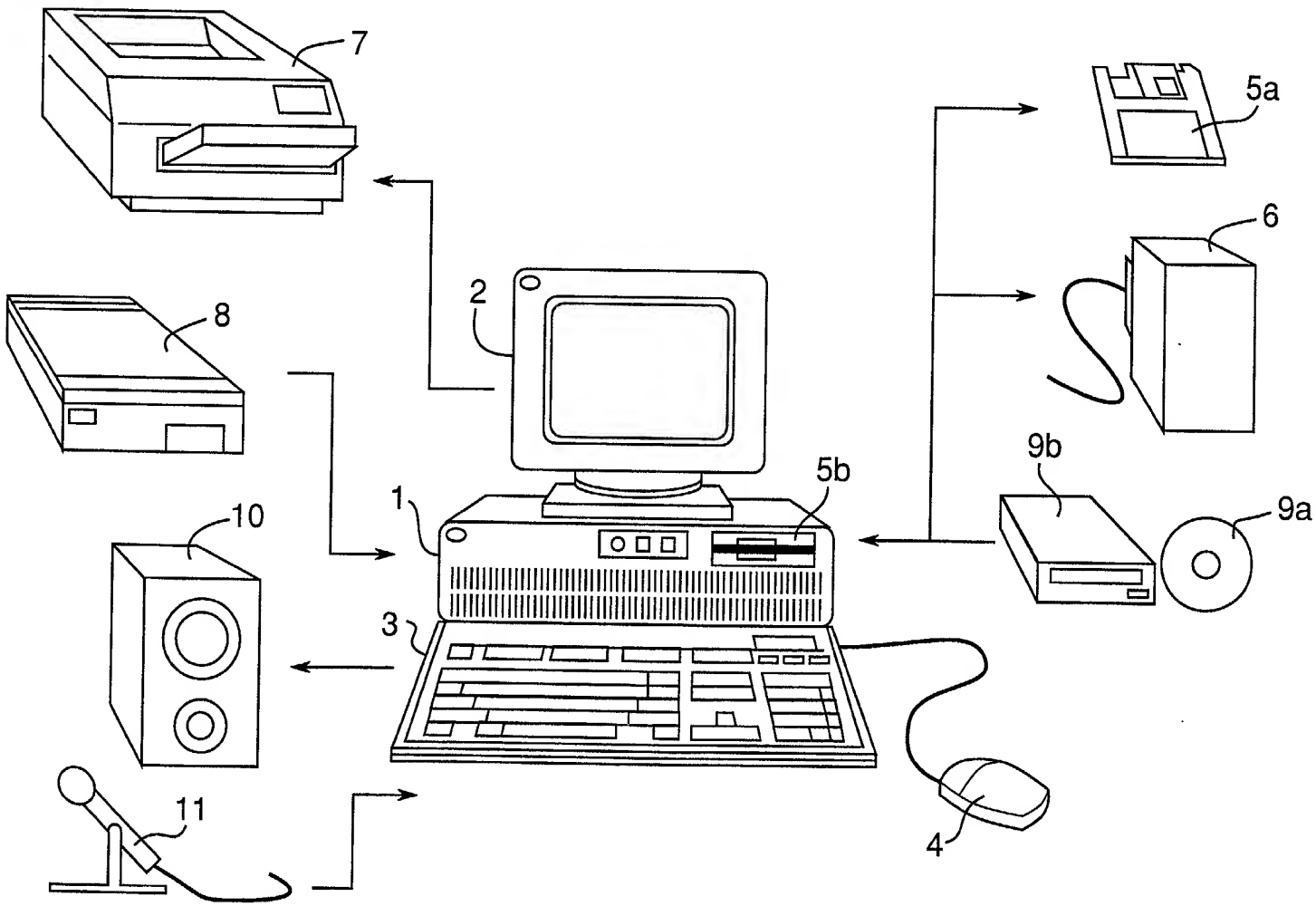

Fig.2

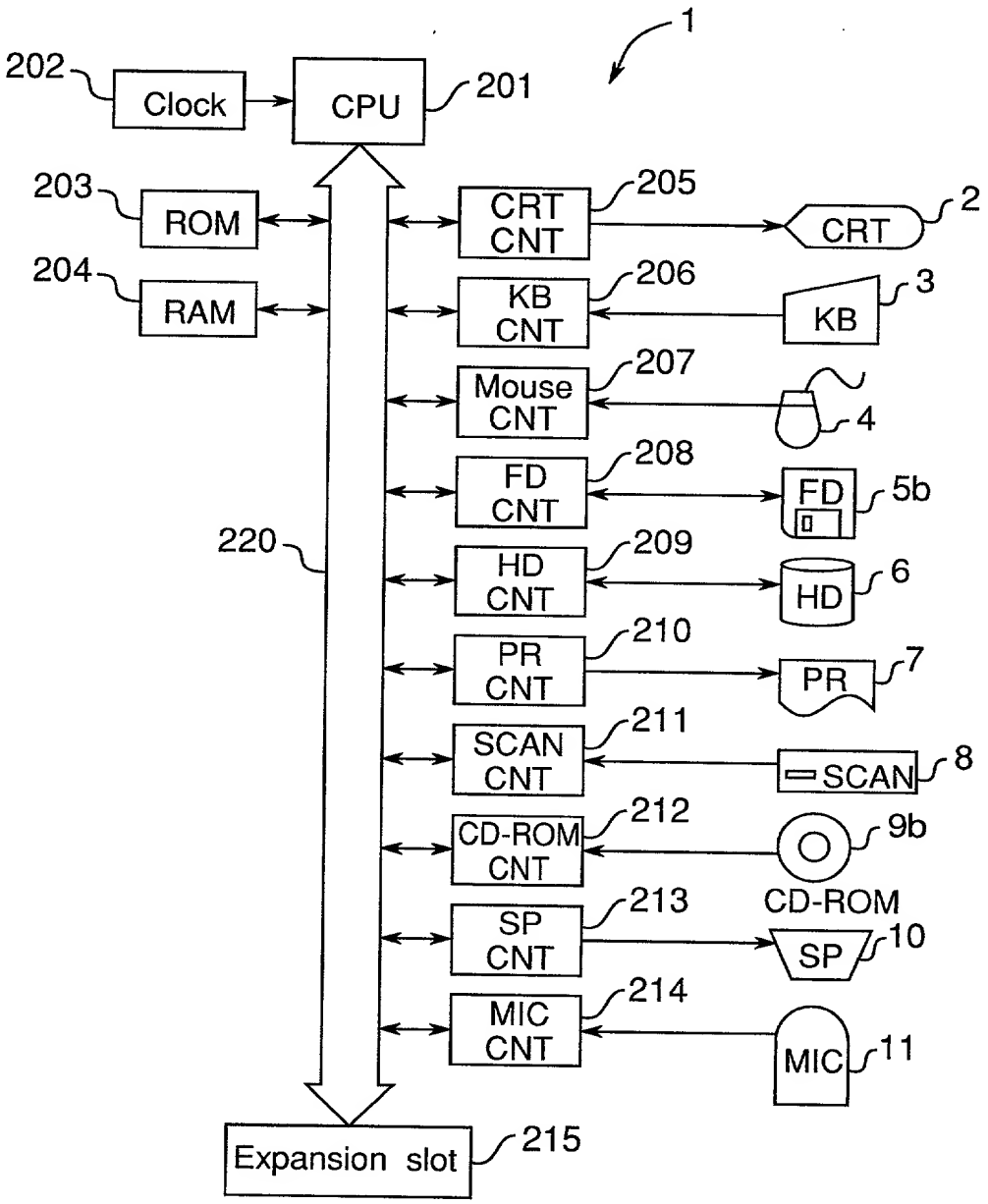
1
202
Clock
CPU
201
203
ROM
204
RAM
220
CRT CNT
205
CRT
2
KB CNT
206
KB
3
Mouse CNT
207
4
FD CNT
208
FD
5b
HD CNT
209
HD
6
PR CNT
210
PR
7
SCAN CNT
211
SCAN
8
CD-ROM CNT
212
9b
CD-ROM
SP CNT
213
SP
10
MIC CNT
214
MIC
11
Expansion slot
215

Fig.3

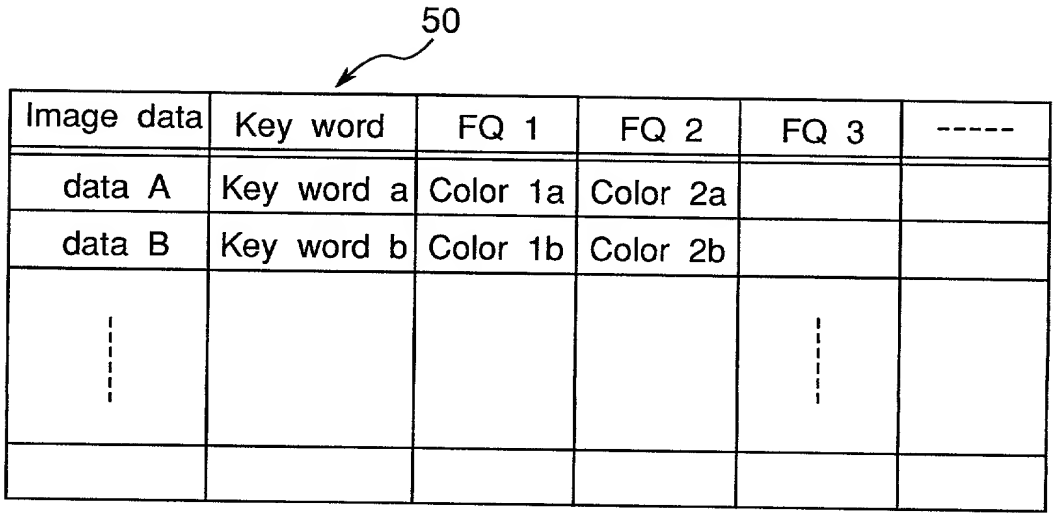
50
Image data
Key word
FQ 1
FQ 2
FQ 3
-----
data A
Key word a
Color 1a
Color 2a
data B
Key word b
Color 1b
Color 2b

Fig.4

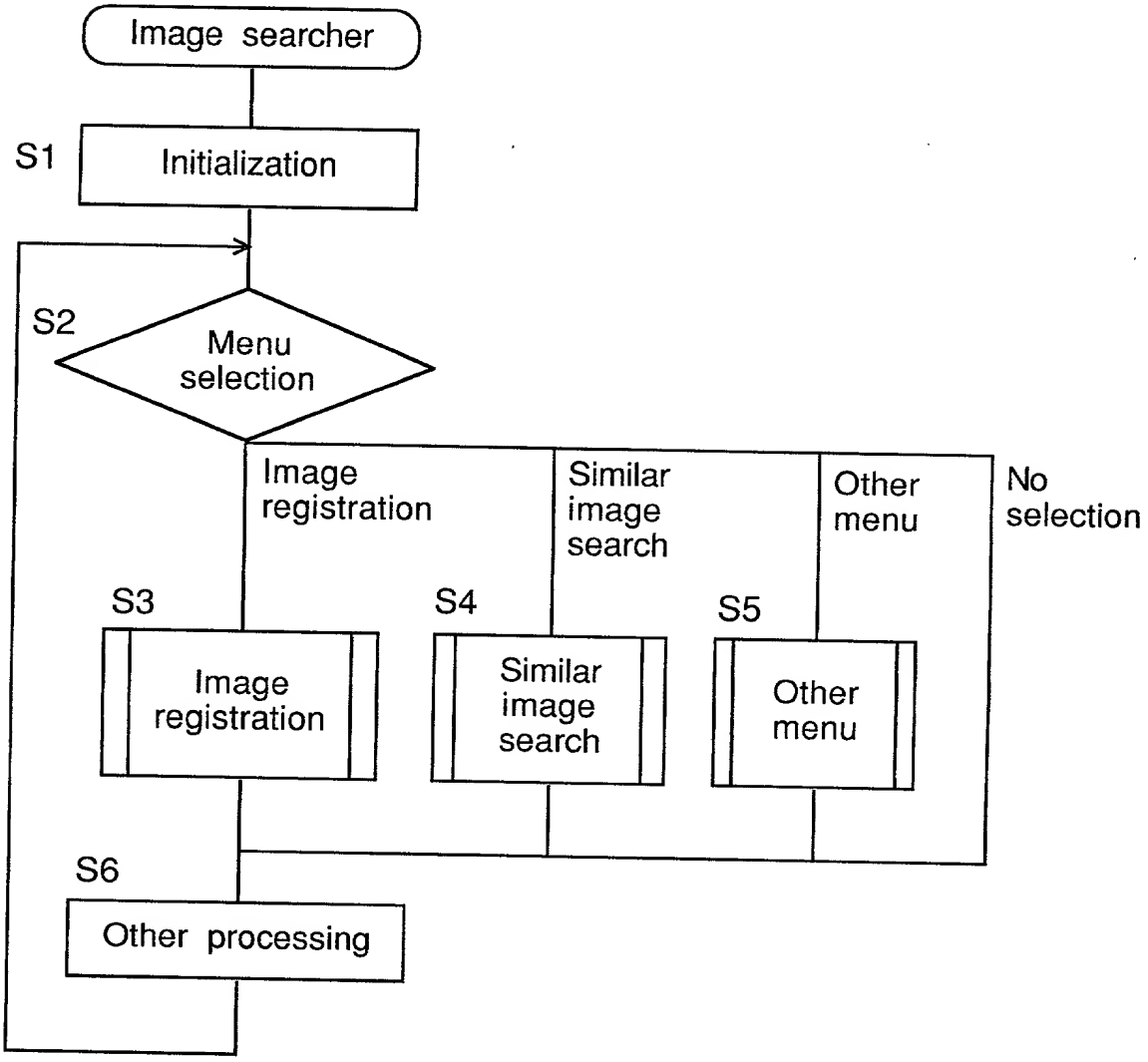
Image searcher
S1
Initialization
S2
Menu selection
Image registration
Similar image search
Other menu
No selection
S3
Image registration
S4
Similar image search
S5
Other menu
S6
Other processing

Fig.5

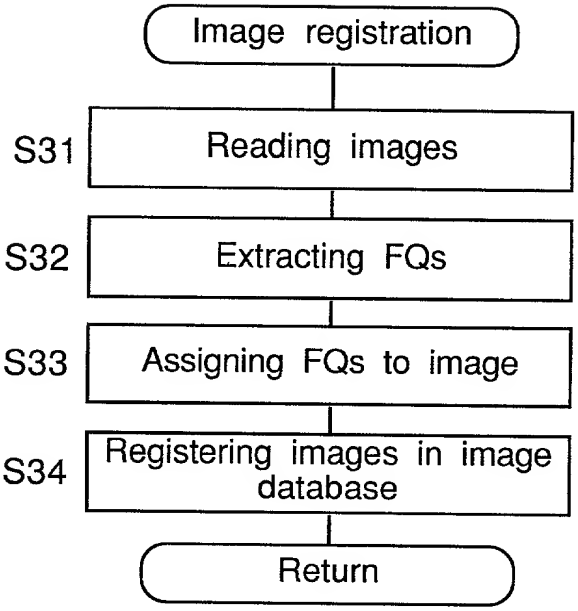
Image registration
S31
Reading images
S32
Extracting FQs
S33
Assigning FQs to image
S34
Registering images in image database
Return

Fig.6

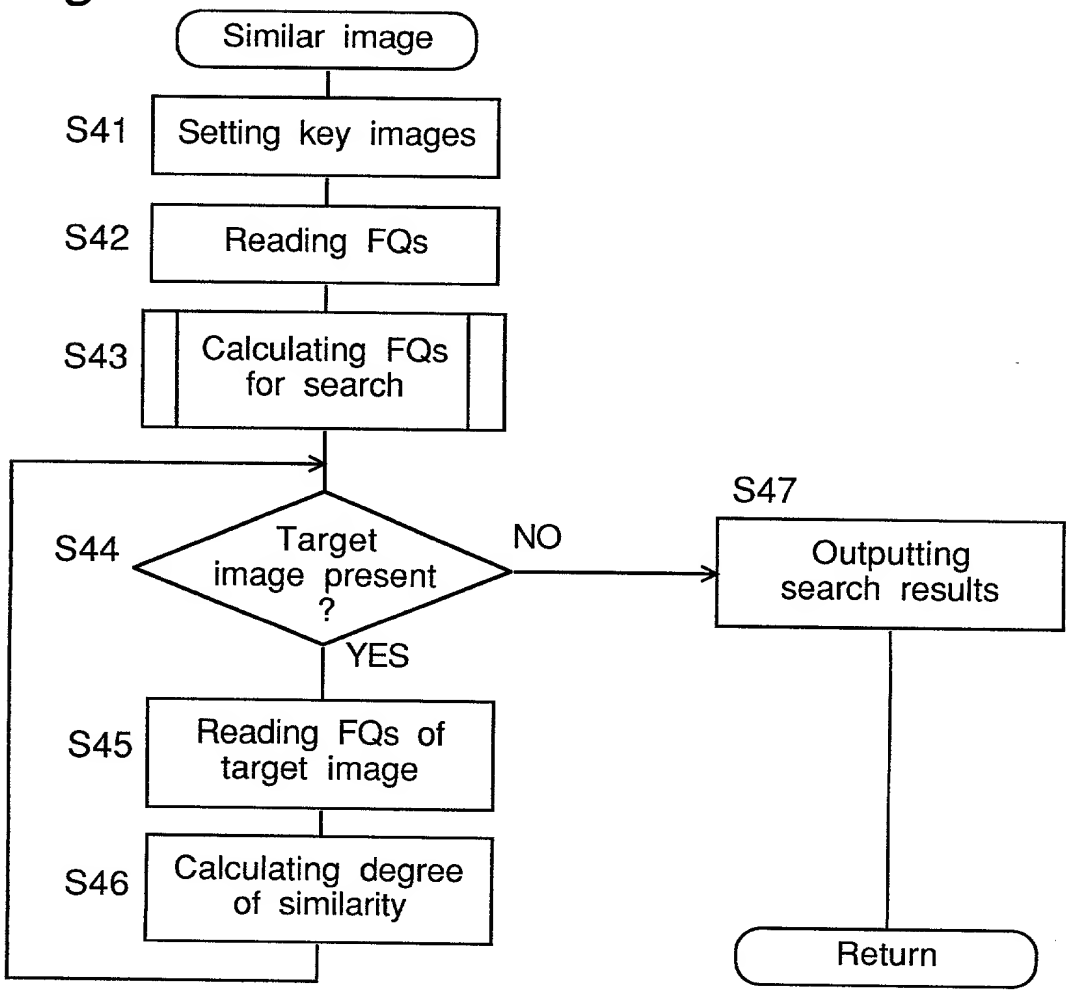
Similar image
S41
Setting key images
S42
Reading FQs
S43
Calculating FQs for search
S44
Target image present ?
NO
S47
Outputting search results
YES
S45
Reading FQs of target image
S46
Calculating degree of similarity
Return

Fig.7

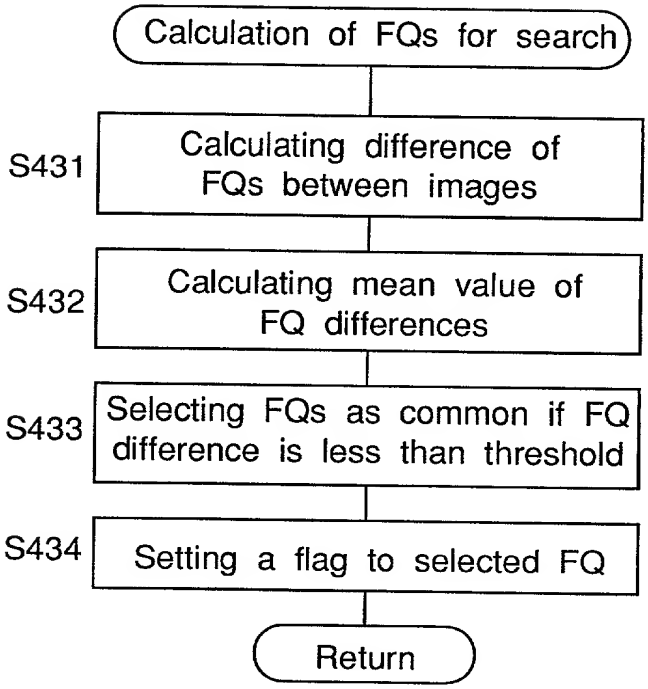

Fig.8

	FQ 1	FQ 2	FQ 3	FQ 4	FQ 5
| Image 1—Image 2 |	1.730	0.010	0.020	0.030	1.790
| Image 2—Image 3 |	2.850	0.000	0.010	3.400	1.140
| Image 1—Image 3 |	1.120	0.010	0.010	3.430	0.550
Mean value	1.900	0.007	0.013	2.287	1.160
Flag of common FQ	0	1	1	0	0

Fig.9

	FQ 1	FQ 2	FQ 3	FQ 4	FQ 5
Key image 1	3.120	6.020	5.470	7.980	0.530
Key image 2	4.850	6.010	5.450	7.950	2.320
Key image 3	2.000	6.010	5.460	4.550	1.080
Mean value	3.323	6.013	5.460	7.827	1.310

Fig.10

	FQ 1	FQ 2	FQ 3	FQ 4	FQ 5
Target image	3.230	6.000	4.100	5.640	1.030

Fig.11

	Mean value of common FQ	Target image
FQ 2	6.013	0.013
FQ 3	5.460	1.360
Distance	——	1.360
Degree of similarity	——	0.735 ~a

Fig.12

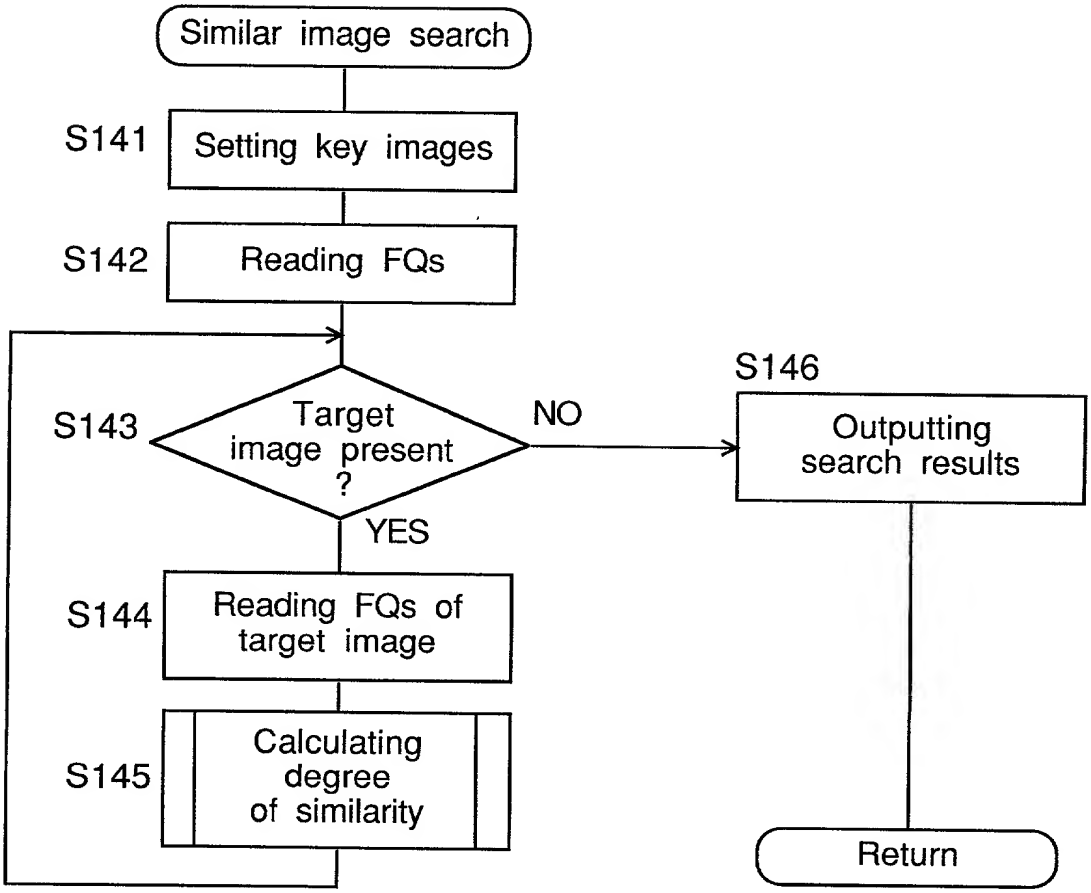
Similar image search
S141
Setting key images
S142
Reading FQs
S143
Target image present ?
NO
S146
Outputting search results
YES
S144
Reading FQs of target image
S145
Calculating degree of similarity
Return

Fig.13

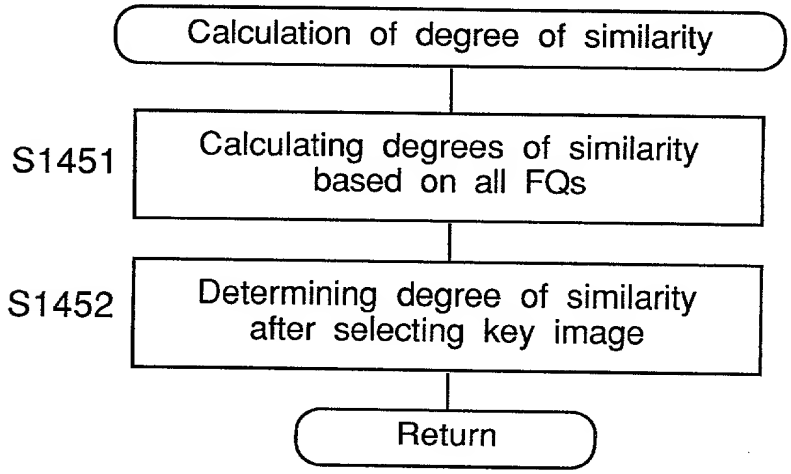
Calculation of degree of similarity
S1451
Calculating degrees of similarity based on all FQs
S1452
Determining degree of similarity after selecting key image
Return

Fig.14

	Key image 1	Key image 2	Key image 3
Distance of FQ 1	0.110	1.620	1.230
Distance of FQ 2	0.020	0.010	0.010
Distance of FQ 3	1.370	1.350	1.360
Distance of FQ 4	2.340	2.310	1.090
Distance of FQ 5	0.500	1.290	0.050
Distance	2.760	3.383	2.186
Degree of similarity	0.3623	0.296	0.457 ~b

Fig.15

	a	Weight	Weighted degree of similarity
Degree of similarity of common FQ	0.735	1.500	1.103
Degree of similarity of all FQs	0.457	1.000	0.457
Degree of similarity	—	—	0.624

b

c

Attorney Docket No.

DECLARATION AND POWER OF ATTORNEY

As a below-named inventor, I hereby declare that:

My residence, post office address and citizenship are as stated below next to my name;

I believe that I and the other joint inventors named below are the original, first and joint inventors of the subject matter which is claimed and for which a patent is sought on the invention or discovery entitled

AN IMAGE SEARCHING SYSTEM AND IMAGE SEARCHING METHOD, AND A RECORDING MEDIUM STORING AN IMAGE SEARCHING PROGRAM

the specification of which (X) is attached hereto;
( ) was filed on _____ as U.S. Ser. No._____.

I have reviewed and understand the contents of the above-identified specification, including the claims; and

I acknowledge the duty to disclose to the Patent and Trademark Office all information known to me which is material to patentability as defined in 37 C.F.R. § 1.56.

I hereby claim foreign priority benefits under 35 U.S.C. § 119/365 of any foreign application for patent or inventor's certificate as listed below or of any PCT international application, designating at least one country other than the United States of America, as listed below and have also identified below any foreign application for patent or inventor's certificate or any PCT international application, designating at least one country other than the United States of America, directed to said invention or

discovery and having a filing date before that of the applications on which priority is claimed:

NUMBER	COUNTRY	DATE FILED	PRIORITY CLAIMED (Yes)	(No)
10-41989	Japan	February 24, 1998	x	

I hereby appoint:

Dale B. Nixon, Reg. No. 28,454
William R. Gustavson, Reg. No. 29,160
David L. Hitchcock, Reg. No. 30,067
Roger N. Chauza, Reg. No. 29,753
Eugenia S. Hansen, Reg. No. 31,966
James W. Williams, Reg. No. 20,047
Steven P. Rhines, Reg. No. 38,595
Thomas N. Tarnay, Reg. No. 41,341
Daren C. Davis, Reg. No. 38,425

all of the firm of SIDLEY & AUSTIN, my representatives with full power of substitution and revocation, to prosecute this application and to transact all business in the United States Patent and Trademark Office connected therewith, and to file and prosecute any international patent applications filed thereon before any international authorities under the Patent Cooperation Treaty.

Send correspondence to:
SIDLEY & AUSTIN
717 N. Harwood
Suite 3400
Dallas, Texas 75201-6507

Direct telephone calls to:
James W. Williams
Direct: (214) 981-3328
Main: (214) 981-3300
Attorney Docket No.:

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on

information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code, and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

Full name of first joint inventor:

Sumiyo TANAKA
First Middle Last

Inventor's signature: Sumiyo Tanaka
Date: Feb. 15. 1999
Residence: Osaka-Shi, Osaka, Japan

Citizenship: Japan
Post Office Address: c/o MINOLTA Co., Ltd., Osaka Kokusai Building, 3-13, 2-chome, Azuchi-machi, Chuo-ku, Osaka-shi, Osaka 541-8556, Japan

Full name of second joint inventor:

First Middle Last

Inventor's signature: _____
Date: _____
Residence: _____

Citizenship: _____
Post Office Address: _____